Aquatic Study Category, **Appendix D**

Study Topic	**File Date**
West Virginia Macroinvertebrate Study	11/2000
West Virginia Stream Chemistry Study	4/8/2002
Kentucky Macroinvertebrate Study	10/2001
Survey of Eight Aquatic Insect Orders Associated with Small Headwater Streams Subject to Valley Fills from Mountaintop Mining	11/02/2002
Fisheries Study	10/12/2002
Aquatic Impacts Statistical Report	4/15/2003
Workshop on the Value of Headwater Streams	4/2000
Flow Origin, Drainage Area, and Hydrologic Characteristics for Headwater Streams in the Mountaintop Coal-Mining Region of Southern West Virginia, 2000-01	3/2003
Reconnaissance of Stream Geomorphology, Low Streamflow, and Stream Temperature in the Mountaintop Coal-Mining Region, Southern West Virginia, 1999-2000	2001
Wetlands Study	11/8/2001
Aquatic Ecosystem Enhancement	1/12/2000

Macroinvertebrate and water quality studies were performed in several watersheds located in both West Virginia and Kentucky to assess the impact of MTM/VF on aquatic resources. Hydrologic and biological studies were also conducted in several West Virginia streams in an effort to demarcate ephemeral, intermittent, and perennial stream zones.

West Virginia Macroinvertebrate Study by EPA Region III, Wheeling Field Office

The study had the following objectives:

> *Characterize and compare conditions in three categories of streams: 1) streams that are not mined; 2) streams in mined areas with valley fills; and 3) streams in mined areas without valley fills. Characterize conditions and describe any cumulative impacts that can be detected in streams downstream of multiple fills. Characterize conditions in sediment control structures (ditches) on MTR/VF operations.*

The data indicated that streams with both valley fills and residences in their watersheds appeared to be more impaired than streams with only valley fills (no residences) in their watersheds. Biological conditions at the unmined sites were compared to a broad state-wide wadeable streams reference condition developed by the West Virginia Department of Environmental Protection (WVDEP). This reference condition was based on a data set of 1268 benthic samples collected from 1996 to 1998. This reference condition defines condition categories of very good, good, fair, poor and very poor based on Stream Condition Index (SCI) scores. Scores in the fair, poor and very poor range are impaired relative to the reference condition. Biological conditions in the filled sites generally represented a gradient of conditions from poor to very good. Biological conditions in streams with filled/residential sites (filled sites that also have residences in their watersheds) represented a gradient of conditions from poor to fair.

Biological conditions in the filled and filled/residential classes were recognizably different from conditions in the unmined class and were impaired relative to conditions in the unmined class, based on the WV SCI scores. The filled/residential class was the most impaired class. The causes of impairment in this class could include several stressors (e.g. the valley fills, the residences, roads). It is impossible to apportion the impairment in this class to specific causes with the available data.

Cumulative impacts downstream of multiple fills were not successfully determined although biological conditions were impaired at the downstream sites compared to the upstream sites. The observed impairment could be caused by several stressors, including mining and residential land use which could not be separated.

Only one sediment control structure was selected as candidate monitoring site since most sites were not reconstructed as streams. Therefore, the objective to characterize these structures was not met.

Questions remain concerning the extent to which downstream impacts identified in this study may be influenced by the size, number, and age of fills and the impact that these changes in the macroinvertebrate community may have on the downstream terrestrial and aquatic communities. A limiting factor that should be considered is that most sites evaluated as mined were not necessarily reflective of current mining methods and programmatic controls. These questions will require additional investigation.

Kentucky Macroinvertebrate Study by EPA Region IV

This study was designed with the following objective:

> *Determine if streams in mined watersheds were being impacted by mountaintop mining and valley fill (MTM/VF).*

Measures of *in situ* water quality, habitat quality and macroinvertebrate community structure were found to be related to mining activities. In particular, conductivity was considerably higher at all

mined sites than it was at reference sites. Conductivity produced the strongest correlation to indicators of macroinvertebrate community health suggesting this as either a route by which impairment occurred in mined areas, or that conductivity is a surrogate for other factors that were not measured. Severe impact to the mayfly (Ephemeroptera) fauna was exhibited at all mined sites. Habitat scores, generally lower at sampling locations downstream of mined areas than at reference sites, were correlated to several measures of diversity and dominance of key groups of macroinvertebrates. Impacts of MTM/VF activities in eastern Kentucky were evident based on stream biological and habitat indicators. Mine sites generally had higher conductivity, greater sediment deposition, smaller substrate particle sizes, and a decrease in pollution sensitive macroinvertebrates with an associated decrease in taxa diversity compared to reference sites.

However, just as in the West Virginia Study, no attempt was made to correlate changes in water quality or quantity and subsequent changes in the macroinvertebrate community to the numbers of valley fills present, the age of the fills, size of the fills or the influences that downstream distance may have on the sampling results. Also, sampling periods for the Kentucky study were limited. As such, additional studies are needed to more fully evaluate the impacts of valley fills on the aquatic and indirectly on the terrestrial community.

Survey of Eight Aquatic Insect Orders Associated with Small Headwater Streams Subject to Valley Fills from Mountaintop Mining by Stout, Wallace, et. al.

The objective of this study was:

Assess the potential limits of viable aquatic communities based on biological criteria.

Six headwater sites in West Virginia and two sites in Kentucky were selected for study. Six of the eight sites had three or more headwater streams planned for valley fills. A total of 34 streams and spring seeps were surveyed in West Virginia and Kentucky, which included 175 sampling locations or stations. Each headwater stream or spring seep was located in the field, where the contiguous surface flow began. Other sampling locations were located 50, 150, 350, and 550 meters downstream of the point of contiguous flow. Aquatic stages were taken with a D-frame net and/or hand picked with forceps from rocks, twigs and branches, leaf-packs and other substrate. Organisms (macroinvertebrates) were counted and identified to the family or genus level and the data recorded on field sheets.

Most sites would not be considered streams based on existing USGS 1:24000 topographic maps. However, a number of taxa that are found in these extreme headwaters have multi-year life cycles suggesting that sufficient water is present for long-lived taxa to complete their juvenile development prior to reaching the aerial adult stage. The predominance of shredder taxa in the headwaters suggests that the community structure in the extreme headwaters resemble those hypothesized by the river continuum concept for first order streams (Vannote et al. 1980). These streams all drained forested regions and leaf material from the surrounding forest was by far the most evident energy source.

Invertebrates inhabiting temporary streams can have high diversity and faunal similarity with permanent streams, therefore they should be considered in conservation plans designed to protect species and their habitats.

New questions remaining: Much more work is needed on organic matter dynamics, e.g., input and output budgets, etc. in small headwater streams of the central Appalachians. The trend of increasing fine organic particle collectors downstream and higher shredder populations upstream suggests a system that is dependent on linkages upstream resources and surrounding forest.

West Virginia Stream Chemistry Study by EPA Region III, Wheeling Field Office

The objectives of this study were the following:

> *Characterize and compare conditions in three categories of streams: 1) streams that are not mined;2) streams in mined areas with valley fills; and 3) streams in mined areas without valley fills. Characterize conditions and describe any cumulative impacts that can be detected in streams downstream of multiple fills.*

Thirty seven (37) sites were divided into three watershed categories: unmined, mined, and filled. The initial evaluation seeks to identify parameters likely to be impacted by MTM/VF mining**.** The average water quality at all Filled sites is compared to the water quality at all Unmined sites sampled during this study. A second approach in this evaluation is to identify the samples and sites which exceeded West Virginia's stream water quality criteria. Sites which have multiple violations are described and characterized.

The data indicate that MTM/VF mining activities increase concentrations of the several parameters in streams. Sites in the Filled category had increased concentrations of the following parameters: sulfate, total calcium, total magnesium, hardness, total dissolved solids, total manganese, dissolved manganese, specific conductance, total selenium, alkalinity, total potassium, acidity, and nitrate/nitrite. There were increased levels of sodium at sites in the category Filled/Residences which may be caused by road salt and/or sodium hydroxide treatment of mine discharges.

The data were inconclusive for several other parameters which were detected in only a few samples or at very low concentrations. Those parameters: total phosphorous, total copper, total lead, total nickel, total barium, total zinc, total organic carbon, dissolved organic carbon, and total suspended solids. Other parameters were detected but there was no clear indication of stream impacts resulting from MTM/VF mining operations. Those parameters are: chloride, total aluminum, dissolved aluminum, total iron, dissolved iron, temperature, dissolved oxygen, and pH. Data indicated that only three samples for total aluminum exceeded the stream criterion and all were collected August 9, 2000 at sites with fills upstream. Dissolved aluminum was detected in only five samples and all were near the detection limit of 100 ug/L. There were no samples for total iron exceeding the stream criterion but several samples in the category Filled approached the limit in the fall of 2000. Dissolved iron was detected at a few sites in the category Filled at levels slightly higher than other

sites. MTM/VF mining operations can increase iron concentrations in streams but there is no clear evidence that this occurred during the study. Temperature, pH, conductivity, and dissolved oxygen were measured in the field. The only field parameter clearly impacted by MTM/VF mining was conductivity which was noticeably increased at sites in the Filled category.

The initial sampling was discarded for quality control reasons. Only the data from the second half of the study was used to evaluate compliance with stream limits due to problems with contamination in blanks and excessive holding times which occurred during the first part of this study. All sampling data used was fully compliant with QA/QC procedures. The latter data indicate that MTM/VF mining is associated with violations of the current stream water quality criteria for total selenium. Selenium violations were detected in each of the five study watersheds and all were at sites in the Filled category, downstream of MTM/VF operations. No other site categories had violations of the selenium limit. The data do not support a conclusion regarding stream water quality violations for aluminum, dissolved oxygen, iron or pH which can be impacted by MTM/VF mining activities.

A number of questions or issues remain to be resolved. Several stream quality parameters exhibited anomalous concentrations. The potential effects of existing mineralogical or geological controls on water quality composition is uncertain. The extent to which downstream impacts may be influenced by the size, number and age of fills and the extent to which downstream distance may influence study findings was not determined. Loss of the initial sampling data made analysis of seasonal variation of water quality difficult to evaluate. Identification of the specific sources of pollutants were not incorporated into the study design. A limiting factor that should also be considered is that most sites evaluated as mined were not necessarily reflective of current mining methods and programmatic controls. As such, further data analysis concerning these issues is being considered.

Fisheries Study by Dr. Jay Stauffer, Pennsylvania State University

This study was designed to answer the following questions:

> *Characterize the fish communities that exist in the primary region of mountain top removal/valley fill coal mining in West Virginia and Kentucky. Determine if any unique fish populations exist in this area. Evaluate the effects of these mining operations on fish populations residing in downstream areas*.

Fish assemblages were sampled in 58 sites in West Virginia located on 1st through 5th order streams, and in 15 sites in Kentucky located on 2nd, 3rd, and 4th order streams. Sites were selected in consultation with U.S. EPA personnel to characterize the fish communities in the primary region of mountaintop removal/valley fill coal mining.

Due to the confounding effects of drought, small stream size (low stream order), and human impact on reference sites in West Virginia, a comparison of reference (unmined) sites to filled sites could

not be made directly during the 1999/2000 sampling season. Comparisons of unmined sites and filled sites in Kentucky and in 2nd order streams in the New River Drainage indicate that mountaintop mining/valley fill coal mining has impacted the streams. In general, the number of total species and benthic species were substantially lower in filled sites that in mined sites in both Kentucky and 2nd order streams in the New River Drainage.

The uniqueness of this area is emphasized by the collection of species of *Cottus* with features that are rare in the population. The continued disruption of streams may eliminate the genetic diversity that may lead to speciation. Further observations and studies are suggested.

Aquatic Impacts Statistical Report by EPA Cincinnati Laboratory

The questions this report was designed to answer are as follows:

> *Is the biological condition of streams degraded by mining compared to unmined areas? Are there additive (cumulative) impacts downstream of mining compared to unmined areas?*

Databases were assembled from mining companies MTM EIS technical studies for chemistry, fish, and macroinvertebrates. Statistical analyses were applied to the data using accepted indices and comparisons to determine correlation of parameters in unmined, filled, filled/residential and mined sites. The analysis indicates that biological integrity is impaired by mining. Unmined sites have a higher biotic integrity. Unmined sites have more taxa and more sensitive taxa. The strongest association with water chemistry suggested that zinc, sodium, and sulfate concentrations were negatively correlated with fish and macroinvertebrate impairments. Selenium and zinc were negatively correlated with the West Virginia Stream Condition Index (WVSCI). The potential drivers of the impaired condition are mining practices and material handling practices and the geological factors associated with specific coal seams and overburden.

The limitations of the study include lack of data on the age of fills, size of fills, characterization of materials handling practices, the influence of specific geological factors such as coal seams and overburden, and the extent to which distance between fills and sample sites affects study findings. There was little QA/QC data provided for the mining company data. Questions still remain on the downstream impacts relative to the size, number and age of fills and the influence of stream flow variations. Further data analysis concerning these issues is being considered. The report for this study was completed in April 2003 and did not undergo EIS Steering Committee review. Continued sampling at Unmined and Filled sites would improve the understanding of whether MTM/VF activities are associated with seasonal variation in benthic macroinvertebrate metrics and base-flow hydrology.

Workshop on the Value of Headwater Streams by U.S. Fish and Wildlife Service

The FWS Pennsylvania Office hosted this workshop April 13, 1999, to review research findings and provide an opportunity for discussion among research scientists and technical staff in the agencies responsible for the EIS. The workshop was proposed to gather information to answer the following questions:

> *At what point in the upper reaches of a stream do regulators stop regulating? How far upstream should we regulate to ensure that downstream functions and quality are maintained? Are stream classifications such as perennial, intermittent, or ephemeral ecologically useful or even relevant in this context? In evaluating the cumulative impacts of more than one valley fill, what size watershed do we evaluate? How many streams can be eliminated by valley filling in a given watershed before the downstream aquatic ecosystem is unacceptably impaired? If we assume that the amount of overburden material that needs to be disposed of is a constant, is one valley fill or a few very large valley fills better for the environment that more numerous small valley fills at the upper reaches of more valleys?*

The proceedings provide information on the current knowledge about headwater streams, which are little understood outside of scientific circles. Meeting participants discussed the fact that historically, small streams may have been under-protected by regulatory agencies because of uncertainty about their values. An industry representative discussed potential opportunities to create wetlands and stream channels as part of reclamation. The stream experts raised concern that many headwater streams were being eliminated by valley filling with no requirement for pre-impact biological inventories, and that many species may be unknowingly lost from the study area's unique ecosystem. They also stressed the importance of small, forested headwater streams and their associated biological communities in providing organic production that feeds downstream aquatic ecosystems. Opinions were expressed that although the current knowledge is far enough advanced to be able to say that headwater streams are too important to be eliminated, the current information is not sufficient to be able to decide what portions of watersheds can be filled before aquatic ecosystems are unacceptably impacted.

As this was an educational symposium and not a specific investigation, there are no study limitations to discuss.

Reconnaissance of Stream Geomorphology, Low Streamflow, and Stream Temperature in the Mountaintop Coal-Mining Regions, Southern West Virginia, 1999-2000 by U.S. Geologic Survey

The objective of this study was to provide the following information:

> *Present comparisons of streambed materials, stream-channel characteristics, low streamflow, and stream temperature among sites with and without valley fills.*

The effects of MTM/VF created in southern West Virginia were investigated by comparing data collected at valley-fill, mined, and unmined sites. Bed material downstream of valley-fill sites had a greater number of particles less than 2 millimeters and a smaller median particle size than the mined sites. Bankfull cross-sections areas at a riffle section were approximately equal at valley-fill and unmined sites, but not enough time had passed and insufficient streamflows since the land was disturbed may have prevented the stream channel at valley-fill sites from reaching equilibrium. Daily streamflows from valley-fill sites generally were greater thatn daily streamflows from unmined sites during periods of low streamflow. Valley-fill sites have a greater percentage of base-flow and a lower percentage of flow from storm runoff than unmined sites. Water temperatures from a valley-fill site exhibited lower daily fluctuations and seasonal variations than water temperatures from an unmined site.

Continued investigation at Unmined and Filled sites would improve the understanding of how MTM/VF activities are associated with seasonal variation in stream geomorphology, stream temperature and base-flow hydrology.

Flow Origin, Drainage Area, and Hydrologic Characteristics for Headwater Streams in the Mountaintop Coal-Mining Region of Southern West Virginia, 2000-01 by U.S. Geologic Survey

The objective of this study was to provide the following information:

> *Determine the median drainage area upstream of ephemeral/ intermittent/perennial flow boundaries in the Mountaintop Coal Mining Region of Southern West Virginia.*

State and Federal rules define stream reaches based on a variety of physical or biological characteristics such as navigability, ordinary high water marks, flow conditions, biological activity, or some combination of these attributes.

A field investigation using a hydrologic protocol developed by the United States Geological Survey (USGS), West Virginia Water Resources Division District Office, was undertaken to illustrate the size of watersheds attributable to each type of stream segment within the study area using this type of approach. To establish the ephemeral/intermittent demarcation (E-point), the field investigation was undertaken during the Spring of 2000, when the ground water table was considered to be at its

maximum. To establish the intermittent/perennial demarcation (P-point), the field investigation was undertaken during the Fall of 2000, when the ground water table was considered to be at its minimum. The locations were documented with GPS and mapping. The results are as follows. The drainage areas for the ephemeral/intermittent boundary (E-point) varied from 6 to 45acres, with a median of 14 acres. The drainage areas for the intermittent/perennial boundary (P-point) ranged from 10 acres up to 150 acres, with a median of 41 acres.

Wetlands Study by EPA Region III

The study was designed to answer the following questions:

> *To what degree are the drainage control measures being established on fills able to replace aquatic habitats that existed prior to construction of the fill, and can designs be modified to further enhance or accomplish this?*
>
> *Regarding the effectiveness of existing forms of mitigation associated with valley fills in replacing or providing substitute resources, can existing forms of mitigation be modified to further enhance or accomplish this?*

It has been reported that wetland communities are being established at reclaimed mine sites, often within sediment retaining structures, or in other ponded areas on the mined sites. The extent of these areas, or the functions they are providing, however, was uncertain. To gather information in this regard, a field team performed functional assessments (water quality, wildlife, and sediment trapping) of ten wetland sites suggested by coal companies. The Evaluation of Planned Wetlands (EPW) technique developed by Environmental Concern, Inc. was utilized to perform these field assessments. EPW is rapid-assessment procedure designed for use during the planned wetland process.

The functions being provided by the wetland systems studied were varied. Many of the wetland systems were providing excellent sediment stabilization functions, and a few were providing good water quality (defined as the capacity to retain and process dissolved or particulate materials to the benefit of downstream surface water quality) and wildlife functions. Sediment stabilization is not a difficult function to establish in a wetland system. Water quality functions such as nutrient retention are also possible to establish with modest planning. In many of these cases where this function was not being provided, we suspect that the wetland systems were largely unplanned, and that the low percent vegetative cover was a significant influence in the low score. Finally, wildlife functions are highly dependent on the vegetative communities present, the degree of interspersion, and other physical and biological features of the system. It is not surprising, therefore, to see that this function did not score highly in many of the linear systems studied. Those areas that scored highly for wildlife function tended to be older systems with more complex structures.

Advanced planning could improve the modest wetland functions evident at existing surface mining facilities.

Aquatic Ecosystem Enhancement by U.S. Department of Energy, National Energy Technology Laboratory

The Mountaintop Mining/Valley Fill Environmental Impact Statement (EIS) Steering Committee sponsored a symposium on January 12, 2000 as a forum to present current information regarding aquatic ecosystem enhancement opportunities at mountaintop mining sites. Ecological and stream restoration experts were assembled from a number of disciplines to focus on the subject of stream (or other aquatic area) re-creation on mined sites. The proceedings from this symposium can be viewed at the U.S. Department of Energy, National Energy Technology Laboratory web site http://www.netl.doe.gov.

As this was an educational symposium and not a specific investigation, there are no study limitations to discuss.